Attachment 9.1 – Supporting Documents

Flood Damage Reduction Costs and Benefits

Madera Region – IRWM Implementation Grant Application

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Attachment 9.1, Project B – Ash Slough Arundo Eradication and Sand Removal

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Project B – Ash Slough Arundo Eradication and Sand Removal

Description of project and relationship to other projects in the proposal

This project involves the eradication of *Arundo donax*, a non-native invasive bamboo, from critical portions of Ash Slough, a flood control channel which runs adjacent to the City of Chowchilla. Heavy Arundo infestation in Ash Slough blocks flood flows and causes flood hazards to the nearby city as well as fire hazards, habitat deterioration, and excessive evapotranspiration of water that could otherwise be used to recharge the overdrafted groundwater. The project proponent is Madera County. Through a subcontract with the Chowchilla Water District this project will eradicate Arundo in areas critical to prevent levee failure and flooding of Chowchilla. Because of Arundo's growing habits, it requires three years of herbicide application to effectively eradicate the infestation. The Chowchilla Water District has equipment and trained operators and can accomplish this work at a greatly reduced cost since they maintain nearby channels for their agricultural water deliveries. To further increase flood flow capacity in the slough, the County will also obtain the required permits for sediment removal from the channel. The sediment will be removed by adjacent growers on an in-kind basis since it is a valuable resource which can be used to sand roads, reducing dust and improving air quality.

This project is similar to the Arundo Eradication projects proposed by the Madera Irrigation District. Arundo infestation is a regional problem which was highlighted in the Madera Region IRWMP. Section 7.3.1 of the IRWMP recommends Arundo Eradication as a viable flood control project:

"Clearing *Arundo donax* from the water channels in the County may not stop flooding entirely. However, at a minimum, the water channels should be restored to their intended capacity... The following are the steps involved in the mapping and eradication of *Arundo donax*:

- Because the plant is so invasive and covers wide areas, the first step in effectively eradicating it is mapping its locations. This mapping can be done by employing GPS and geographic information systems (GIS). The mapping will quantify the extent of the problem and help in estimating the cost to eradicate this invasive plant.
- Eradication of *Arundo donax* by spraying and cutting followed by another round of spraying and cutting is the recommended method to be employed. According to the Levee Task Force, *Arundo donax* needs to be sprayed in September to be most effective. The first round is expected to clear 60 to 90 percent of the plant and the second round is expected to clear the remaining plants. This is expected to take 2 to 3 years."[1]

Description of the Project's Economic Costs

This project's economic costs consist of three years of Arundo eradication treatment with the associated monitoring, project management, and other costs. (See Attachment 4.1, page 13 - Detailed project budget and budget notes) as well as yearly administration and maintenance costs. (see Table 17 at the end of this section)

[1] Note, there are some inaccuracies in this information as written in the IRWMP. These are corrected in the work plan and budget of this proposal.

<u>Projects expected flood damage reduction benefits:</u>

Estimates of historic flood damage data: The Ash Slough was constructed, by the Army Corp of Engineers in the 1970's, to contain a 100 year event. Our records show that no flooding has occurred outside of the channel however the ongoing degradation of the channel capacity due to the infestation of Arundo Donax has increased alarm and resulted in the Decertification of the channel. In 2006 the Ash Slough experienced flows equivalent to a 10 year event. 4,000 cubic feet per second (cfs) was conveyed through the slough and although flooding did not occur there was no free board and the magnitude of the flow increased the deterioration of the slough banks.

Estimates of existing without-project conditions: Attachment 9.2, page 3 shows the without-project conditions for a 10 year, 25 year and 100 year event. In the event of a levee failure the inundation area would affect over 2000 properties, 4,500 acres of farmland, 16 miles of roadway. Based on the FRAM the Expected Annual Damages is $3.5 million dollars.

Estimates of existing with-project conditions: Attachment 9.2, page3 shows the with-project conditions for a 100 year event. With this project the Ash Slough will be restored to its original design capacity for a 100 year event with the required 3 foot free board. Once this is complete there is expected to be zero damage caused.

Description of methods used to estimate without- and with-project conditions: A FLO-2D Model was model to determine the area and shape of probable flood inundation area during the events that were analyzed. See Attachment 9.2, page 3 Those shape files were then cross referenced with the County's records to tally data such as the number of improved properties affected, type of property and types crops being farmed on each property. That data was then inputted into the DWR Flood Rapid Analysis Model (FRAM) to determine cost associated with the expected damage and annual benefit of the project. (see Attachment 9.2, page 149)

Description of the distribution of local, regional, and statewide benefits, as applicable:

The benefit to local, regional and statewide would be the deferred cost of support to the area in a flood situation.

Identification of beneficiaries

The beneficiaries of this project are the 2000 citizens of the City of Chowchilla and surrounding landowners identified in the section 9.2, page 3 – FRAM Support Data.

When the benefits will be received

It is expected that monetary benefit will be receive immediately following the completion of this project. The Central Valley Floodplain Evaluation and Delineation (CVFED) program for the Department of Water Resource is in the process of revaluating the floodplain in which it is anticipated the new FEMA maps will reflect the City of Chowchilla as being within the flood plain. With this project the channel will be recertified and the City will be removed from the floodplain and not be required to purchase flood insurance. The value of that insurance is to be equal to the Expected Annual Damages in Table 19 ($3.5 million).

Uncertainty of the benefits
Not applicable.

Description of any adverse effects
The only adverse effect is the degradation of wildlife habitat that my coexist in the thick vegetation, however the Department of Fish and Game has classified the *Arundo Donax* as a noxious weed and has permitted the eradication of it.

Narrative discussion that describes qualifies and supports the values entered into the tables:
The Values entered into the tables were taken from the Fast Rapid Assessment Model (FRAM) and are therefore as accurate as values entered into the FRAM. The values entered into the FRAM were taken from County Assessor and Ag Commissioner records. The FLO-2D Model Evaluation which determined the area and shape of inundation area is explained 9.2, page 149 FRAM Support Data.

Quantification of Flood damage reduction benefits (Table 19)
The main benefit of this project is to eliminate the potential flood damage caused during the analyzed 10, 25 and 100 year rainfall events. Table 19 represents a $3.5 million dollar Expected Annual Damages. Since the with-project conditions will eliminate this expected damage the Expected Annual Damage Benefit is $3.5 million dollars.

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Table 17- Annual Cost of Project (All costs should be in 2009 Dollars) Project: Project B - Ash Slough Arundo Eradication and Sand Removal									
	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost From Table 7 (row (i), column(d))	Admin	Operation	Maintenance	Replacement	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs(g) x (h)
2009							$0	1.000	$0
2010							$0	0.943	$0
2011	$545,348						$545,348	0.890	$485,360
2012	$737,268						$737,268	0.840	$619,305
2013	$737,268						$737,268	0.792	$583,916
2014	$623,584						$623,584	0.747	$465,817
2015		$1,926		$43,369			$45,295	0.705	$31,933
2016		$1,926		$43,369			$45,295	0.665	$30,121
2017		$1,926		$43,369			$45,295	0.627	$28,400
2018		$1,926		$43,369			$45,295	0.592	$26,815
2019		$1,926		$43,369			$45,295	0.558	$25,274
2020		$1,926		$43,369			$45,295	0.527	$23,870
2021		$1,926		$43,369			$45,295	0.497	$22,512
2022		$1,926		$43,369			$45,295	0.469	$21,243
2023		$1,926		$43,369			$45,295	0.442	$20,020
2024		$1,926		$43,369			$45,295	0.417	$18,888
2025		$1,926		$43,369			$45,295	0.394	$17,846
2026		$1,926		$43,369			$45,295	0.371	$16,804
2027		$1,926		$43,369			$45,295	0.350	$15,853
2028		$1,926		$43,369			$45,295	0.331	$14,993
2029		$1,926		$43,369			$45,295	0.312	$14,132
2030		$1,926		$43,369			$45,295	0.294	$13,317
2031		$1,926		$43,369			$45,295	0.278	$12,592
2032		$1,926		$43,369			$45,295	0.262	$11,867
2033		$1,926		$43,369			$45,295	0.247	$11,188
2034		$1,926		$43,369			$45,295	0.233	$10,554
2035		$1,926		$43,369			$45,295	0.220	$9,965
2036		$1,926		$43,369			$45,295	0.207	$9,376
2037		$1,926		$43,369			$45,295	0.196	$8,878
2038		$1,926		$43,369			$45,295	0.185	$8,380
2039		$1,926		$43,369			$45,295	0.174	$7,881
2040		$1,926		$43,369			$45,295	0.164	$7,428
2041		$1,926		$43,369			$45,295	0.155	$7,021
2042		$1,926		$43,369			$45,295	0.146	$6,613
2043		$1,926		$43,369			$45,295	0.138	$6,251
2044		$1,926		$43,369			$45,295	0.130	$5,888
2045		$1,926		$43,369			$45,295	0.123	$5,571
2046		$1,926		$43,369			$45,295	0.116	$5,254
2047		$1,926		$43,369			$45,295	0.109	$4,937
2048		$1,926		$43,369			$45,295	0.103	$4,665
2049		$1,926		$43,369			$45,295	0.097	$4,394
2050		$1,926		$43,369			$45,295	0.092	$4,167
2051		$1,926		$43,369			$45,295	0.087	$3,941
2052		$1,926		$43,369			$45,295	0.082	$3,714
2053		$1,926		$43,369			$45,295	0.077	$3,488
2054		$1,926		$43,369			$45,295	0.073	$3,307
2055		$1,926		$43,369			$45,295	0.069	$3,125
2056		$1,926		$43,369			$45,295	0.065	$2,944
2057		$1,926		$43,369			$45,295	0.061	$2,763
2058		$1,926		$43,369			$45,295	0.058	$2,627
Project Life								…	
Total Present Value of Discounted Costs (Sum of Column (i)) Transfer to Table 20, column (c), Exhibit F: Proposal Costs and Benefits Summaries									$2,675,198
Comments: This project's lifespan is until 2058. Administration costs are estimated at one County Engineering Department employee working on the project for 16 hours per year at a rate of $86.70 per hour. The Maintenance cost of $43,369 is the cost to eradicate sparse Arundo patches from 5 miles of stream through hand cut and backpack spraying.									

(1) The incremental change in O&M costs attributable to the project.

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Table 19 - Present Value of Expected Annual Damage Benefits			
Project Title: Project B - Ash Slough Arundo Eradication and Sediment Removal			
(a)	Expected Annual Damage Without Project (1)		**$3,570,078**
(b)	Expected Annual Damage With Project (1)		**$0**
(c)	Expected Annual Damage Benefit	(a) – (b)	**$3,570,078**
(d)	Present Value Coefficient (2)		**15.76**
(e)	**Present Value of Future Benefits** **Transfer to Table 20, column (e), Exhibit F: Proposal Costs and Benefits Summaries.**	**(c) x (d)**	**$56,264,434**

(1) This program assumes no population growth thus EAD will be constant over analysis period.
(2) 6% discount rate; 50-year analysis period (could vary depending upon life cycle of project).

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Attachment 9.1 Project C – Cottonwood, Dry and Berenda Creek Arundo Eradication and Sand Removal

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Project C – Cottonwood, Dry and Berenda Creek Arundo Eradication and Sand Removal

<u>Narrative Description of Project and its relationship to other projects in the Proposal</u>
There is frequent flooding on Cottonwood Creek, Dry Creek, and Berenda Creek due to invasive plant species, particularly Arundo, overgrown vegetation, and sedimentation which lead to a lack of channel capacity. Without proper capacity, these channels are unable to carry the design flows or flood flows. Arundo infestation is a serious problem in these creeks, obstructing flows either by the density of their stands or from parts of the plants breaking off and plugging culverts, siphons, and other crossing structures. Flow restriction can be seen in photos of Arundo infestation in Cottonwood Creek (see Attachment 9.3, page 3). The reduction of flood damage along these creeks and natural waterways is an essential and critical component of the regional water resources planning as indicated in the Madera Region Integrated Regional Water Management Plan. (See Work Plan for specific citations to relevant sections of the IRWMP)

This project is similar to the Ash Slough Arundo Eradication project proposed by Madera County. Arundo infestation is a regional problem which was highlighted in the Madera Region IRWMP. Section 7.3.1 of the IRWMP recommends Arundo Eradication as a viable flood control project:
"Clearing *Arundo donax* from the water channels in the County may not stop flooding entirely. However, at a minimum, the water channels should be restored to their intended capacity... The following are the steps involved in the mapping and eradication of *Arundo donax*:

> • Because the plant is so invasive and covers wide areas, the first step in effectively eradicating it is mapping its locations. This mapping can be done by employing GPS and geographic information systems (GIS). The mapping will quantify the extent of the problem and help in estimating the cost to eradicate this invasive plant.
>
> • Eradication of *Arundo donax* by spraying and cutting followed by another round of spraying and cutting is the recommended method to be employed. According to the Levee Task Force, *Arundo donax* needs to be sprayed in September to be most effective. The first round is expected to clear 60 to 90 percent of the plant and the second round is expected to clear the remaining plants. This is expected to take 2 to 3 years."[2]

<u>Description of the Project's Economic Costs:</u> This project's economic costs consist of three years of Arundo eradication treatment with the associated monitoring, project management, and other costs. (See Attachment 4.1, page 23 - Detailed project budget and budget notes) as well as yearly administration and maintenance costs. (See Table 11 below)

Cost details for the project – Cost details for the project are in the budget and budget notes (See (See Attachment 4.1, page 23 - Detailed project budget and budget notes). The discount factors in table 9 have been applied to these costs in Table 11. (See Table 11 below).

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[2] Note, there are some inaccuracies in this information as written in the IRWMP. These are corrected in the work plan and budget of this proposal.

<u>Flood Damage Reduction Benefits:</u>

a. Estimates of historic flood damage: The above three creeks are used in the spring and summer as a water conveyance system for the District. These creeks are surrounded by valuable farmland, industrial businesses, homes, and other structures. Flooding of these structures can lead to a significant negative economic impact. A letter of disaster declaration due to flooding damages to crops by Madera County Department of Agriculture, Weights and Measures is included in Attachment 9.3, page 7. It states that in March and April of 2006, Madera County had an estimated crop loss of about $23,050,000 due to flooding and heavy rains.[3] In addition, all three of these creeks cross Highway 99, a major interstate route. The highway bridges at these crossings are narrow and the Highway is at risk of flooding if Arundo canes are washed downstream and block flows. This has happened in the past. Flooding of Highway 99 could lead to economic disruption for the entire state of California.

The MID log book shows incidents of flood damage along these creeks from 1993 – 1997. (see Attachment 9.3, page 67) Unfortunately MID did not keep specific records separating out the historic costs associated with these flood events. Historic photos of the flood events give some idea of the extent of the damage (see Attachment 9.3, page 59)

b. Estimates of existing without-project conditions: There is frequent flooding on Cottonwood Creek, Dry Creek, and Berenda Creek due to invasive plant species, particularly Arundo, overgrown vegetation, and sedimentation which lead to a lack of channel capacity. Without proper capacity, these channels are unable to carry the design flows or flood flows. Arundo infestation is a serious problem in these creeks, obstructing flows either by the density of their stands or from parts of the plants breaking off and plugging culverts, siphons, and other crossing structures. Photos of Arundo infestation in Cottonwood Creek may be found in Attachment 9.3, page 3. It is estimated that with the current conditions, the capacity of the creeks to handle flood flows is reduced from by 75%.

c. Estimates of existing with-project conditions. Flood damage reduction may be accomplished by the eradication of Arundo and sediment removal in the creeks. The eradication of Arundo and removal of sediments along the creeks would not completely eliminate the flooding issues, however, it would lower the probability of flooding occurrences, thus reducing the likelihood of damage. It is estimated that with the Arundo eradication, the flood flows would in increased by at least 75%. This is a conservative engineer's estimate based on experience.

<u>Narrative discussion of values entered in tables</u>

DWR's Flood Rapid Assessment Model (FRAM) was utilized to analyze the benefit and cost ratio of the project as relates to Arundo eradication and sediment removal for flood damage reduction. Three types of storm events (i.e., 2-year, 10-year, and 25-year) were analyzed for

[3] This letter does not distinguish between the damage from the flood events and the damage from the heavy rains, nor does it indicate which creeks flood. However it is useful to show the scale and extent of damage to agricultural lands which can result from flood events.

the last twenty years (1990 – 2009) based on the historical data collected at the MID weather station. Out of these storm events, flood events were identified based on field observations by the MID staff as well as maintenance records for flood damage repairs on the creeks (see Attachment 9.3, page 67). There were a total of five flood events in separate years recorded during this period and these flood events were determined to be associated with 2-year and 10-year storm return periods based on the 10-day cumulative daily precipitation data provided in the City of Madera Storm Drainage Master Plan report (Table 2-1, see Attachment 9.3, page 13). Since the drainage areas for these creeks originate in the foothills at about 1,500 feet in elevation and cover large areas, the numerical values for these storm events for the various return periods should be considerably higher than in the valley area as indicated in the city's Master Plan Table 2.1. Nevertheless, due to the lack of data in the foothills, the valley floor storm data was assumed.

The data show that the five flood years in the creeks were 1993, 1995, 1997, 1998, and 2006. There were a total of twenty-one 2-year storm events and only two of these events caused flooding and damage in the creeks' surrounding areas (i.e., 1997 and 1998). The rest of the three flooding events were associated with the 10-year events, which had a total of four events during 1990-2009. The analysis demonstrated that the probabilities of without- or pre- project structural failure of the creek banks for the 2-year and 10-year storm events are 0.1 (i.e., 2/21) and 0.75 (i.e., ¾), respectively. Since the 25-year storm event was not observed during this period, it was assumed that if it had occurred it would have caused damage with a probability of 1.0 (see Attachment 9.3, page 17 for details of the precipitation and storm event data analysis). However, the with- or post- project probabilities of structural failures were assumed to be 0, 0.5, and 1.0 for the 2-year, 10-year, and 25-year storms. These estimates are conservative since it was observed by John Bese, MID Chief of Operations and Maintenance, that with a flow of 40 cfs at the lower end of Cottonwood Creek the flow depths would rise about four feet higher. This is about doubling the normal flow depth when obstruction is present in the creeks due to Arundo overgrowth. The average channel depth of Cottonwood Creek is about 15-20 feet.

The cropping pattern along the creeks was assumed to be 50 percent almonds and 50 percent grapes, which is similar to the overall cropping pattern of the District. The estimated acreage of flooding is based on observed historical flooding. The areas were delineated on an aerial map by several MID staff, who were able to recall the extent of the flooded areas along the creeks in different storm events (see Attachment 9.3, page 33 for maps of the delineated flood areas). The estimated flood areas for the 2-year, 10-year, and 25-year storms were estimated to be about 700, 4,400, and 4,400 acres, respectively, for the three creeks. Even though the flood acreage between the 10-year and 25-year are the same, the assumed time of inundation is longer for the 25-year storm event due to larger flows and higher flood depths. The inundation time for the small storms were field observed to be less than 5 days, and for the larger storms, the inundation time was observed to be about one week. In order to keep the analysis simple, the damages to a few of the surrounding industrial businesses, homesteads, and potential highway and roadway flood damages were not considered.

Quantified Estimates of Flood Damage Reduction Benefits

As shown in Table 19 below, the Expected Annual Damages without project and with project resulting from the FRAM modeling are $3,924,956 and $3,212,422, respectively (Attachment 9.3, page 39). The annual benefit is $712,534 and the present value of future benefits is $11,229,536. The proposed project cost is budgeted for $2,508,000, and the annual O&M cost is $41,495. The present value of future costs is $2,542,861. Factoring in the water supply benefits, this creates a benefit/cost ratio of 5.7.

The following are attached in 9.3 and provide additional documentation for this section:

Photos of Typical Arundo Infestation in Cottonwood Creek
USDA Secretarial Disaster Declaration Letter
City of Madera Storm Drainage Master Plan Table 2.1
Historical Storm Event Analysis and MID Daily Precipitation Data
Maps of Delineated Flood Areas Along Cottonwood, Berenda, and Dry Creeks
Results of FRAM Analysis
Photos of Flood Damage
MID Historical Damage Log

Table 17- Annual Cost of Project (All costs should be in 2009 Dollars) Project: __Project C - Cottonwood, Dry, and Berenda Creek Arundo Eradication and Sand Removal_									
	Initial Costs	Operations and Maintenance Costs (1)						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost From Table 7 (row (i), column(d))	Admin	Operation	Maintenance	Replacement	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs(g) x (h)
2009							$0	1.000	$0
2010							$0	0.943	$0
2011	$846,250						$846,250	0.890	$753,162
2012	$567,545						$567,545	0.840	$476,738
2013	$408,285						$408,285	0.792	$323,362
2014	$686,065						$686,065	0.747	$512,490
2015		$1,680		$39,815			$41,495	0.705	$29,254
2016		$1,680		$39,815			$41,495	0.665	$27,594
2017		$1,680		$39,815			$41,495	0.627	$26,017
2018		$1,680		$39,815			$41,495	0.592	$24,565
2019		$1,680		$39,815			$41,495	0.558	$23,154
2020		$1,680		$39,815			$41,495	0.527	$21,868
2021		$1,680		$39,815			$41,495	0.497	$20,623
2022		$1,680		$39,815			$41,495	0.469	$19,461
2023		$1,680		$39,815			$41,495	0.442	$18,341
2024		$1,680		$39,815			$41,495	0.417	$17,303
2025		$1,680		$39,815			$41,495	0.394	$16,349
2026		$1,680		$39,815			$41,495	0.371	$15,395
2027		$1,680		$39,815			$41,495	0.350	$14,523
2028		$1,680		$39,815			$41,495	0.331	$13,735
2029		$1,680		$39,815			$41,495	0.312	$12,946
2030		$1,680		$39,815			$41,495	0.294	$12,200
2031		$1,680		$39,815			$41,495	0.278	$11,536
2032		$1,680		$39,815			$41,495	0.262	$10,872
2033		$1,680		$39,815			$41,495	0.247	$10,249
2034		$1,680		$39,815			$41,495	0.233	$9,668
2035		$1,680		$39,815			$41,495	0.220	$9,129
2036		$1,680		$39,815			$41,495	0.207	$8,589
2037		$1,680		$39,815			$41,495	0.196	$8,133
2038		$1,680		$39,815			$41,495	0.185	$7,677
2039		$1,680		$39,815			$41,495	0.174	$7,220
2040		$1,680		$39,815			$41,495	0.164	$6,805
2041		$1,680		$39,815			$41,495	0.155	$6,432
2042		$1,680		$39,815			$41,495	0.146	$6,058
2043		$1,680		$39,815			$41,495	0.138	$5,726
2044		$1,680		$39,815			$41,495	0.130	$5,394
2045		$1,680		$39,815			$41,495	0.123	$5,104
2046		$1,680		$39,815			$41,495	0.116	$4,813
2047		$1,680		$39,815			$41,495	0.109	$4,523
2048		$1,680		$39,815			$41,495	0.103	$4,274
2049		$1,680		$39,815			$41,495	0.097	$4,025
2050		$1,680		$39,815			$41,495	0.092	$3,818
2051		$1,680		$39,815			$41,495	0.087	$3,610
2052		$1,680		$39,815			$41,495	0.082	$3,403
2053		$1,680		$39,815			$41,495	0.077	$3,195
2054		$1,680		$39,815			$41,495	0.073	$3,029
2055		$1,680		$39,815			$41,495	0.069	$2,863
2056		$1,680		$39,815			$41,495	0.065	$2,697
2057		$1,680		$39,815			$41,495	0.061	$2,531
2058		$1,680		$39,815			$41,495	0.058	$2,407
Project Life								…	
Total Present Value of Discounted Costs (Sum of Column (i)) Transfer to Table 20, column (c), Exhibit F: Proposal Costs and Benefits Summaries									$2,542,861

Comments: This project's lifespan is until 2058. Administration costs are estimated at one MID Engineering Department employee working on the project for 40 hours per year at a rate of $42 per hour. The Maintenance cost of $39,815 is the cost to eradicate Arundo from one mile of stream, which is the estimated amount might occur for maintenance purposes.

(1) The incremental change in O&M costs attributable to the project.

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Table 19 - Present Value of Expected Annual Damage Benefits Project: Madera Cottonwood Creek, Berenda Creek, and Dry Creek Arundo Eradication and Sediment Removal			
(a)	Expected Annual Damage Without Project (1)		**$3,924,956**
(b)	Expected Annual Damage With Project (1)		**$3,212,422**
(c)	Expected Annual Damage Benefit	**(a) – (b)**	**$712,534**
(d)	Present Value Coefficient (2)		**15.76**
(e)	**Present Value of Future Benefits** **Transfer to Table 20, column (e), Exhibit F: Proposal Costs and Benefits Summaries.**	**(c) x (d)**	**$11,229,536**

(1) This program assumes no population growth thus EAD will be constant over analysis period.
(2) 6% discount rate; 50-year analysis period (could vary depending upon life cycle of project).

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Attachment 9.1, Project D – Root Creek In-Lieu Groundwater Recharge

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Project D – Root Creek In-Lieu Groundwater Recharge

The Root Creek In-Lieu Groundwater Recharge project will provide flood control benefits by diverting and using San Joaquin floodwater. This will reduce flooding and flood damage along the San Joaquin river corridor.

Water Supplies

The proposed project will use water from three sources: San Joaquin floodwater (Section 215 water), Class II CVP water purchased from Madera Irrigation District, and water purchased under contract from the Westside Mutual Water Company. San Joaquin River floodwater, also called Section 215 water, occurs during high flow periods and large quantities are available for a nominal charge to USBR water contractors. These waters are typically considered a nuisance as they are available in large quantities for short time periods and cause flooding and damage. A simulation of historical hydrology shows that RCWD will be able to divert and use, on average, 2,100 AF/year of San Joaquin River floodwater (see Attachment 9.4, page 3). The floodwater will be used when it is available during the months of March through November, during which there is irrigation water demand in RCWD. The floodwater will be delivered to RCWD through Madera Irrigation District facilities.

With and Without Project

The proposed project will create demand for the floodwater and facilities to divert and use it. As a result floodwater will be diverted from the San Joaquin River causing a reduction in flood flow peaks. Without the project the water will remain in the San Joaquin River and potentially cause flooding and flood damage.

Quantification of Benefits

The quantity of water diverted will be measured by the quantity of floodwater purchased from USBR, and the quantity delivered to RCWD through a new turnout on Lateral 6.2.

Area Benefitted

It is not feasible to identify a specific area that will benefit from the reduction in flood flows. The actual area benefitting could be anywhere along the San Joaquin River corridor. The beneficiaries will be property owners along the San Joaquin River corridor downstream of Root Creek Water District. The benefits will be realized during the life of the project (50 years), and will occur whenever high flows occur on the San Joaquin River, or about one in every three years.

Certainty of Analysis

The USBR has maintained data on San Joaquin River flows for several decades. These flood flows are expected to occur in the future, and the simulation of available Section 215 water supplies is considered accurate and reliable.

Benefit Calculations

Actual flood water diversions will vary with the hydrology and range from 0 AF/year to 9,400 AF/year with an average of 2,100 AF/year. Flood control benefits are provided in Tables 18 and 19 (See below). Table 18 includes an Event Probability of 100%, since the flood diversions of 2,100 AF/year represent a long-term annual average. The annual flood control benefit is estimated to be $115,500/year. The assumptions used in the analysis are provided below:

1. Floodwater diversions will average 2,100 AF/year of San Joaquin River water.
2. Floodwater will inundate low-lying agricultural land along the San Joaquin River corridor to a depth of 2 feet.
3. Flood damage will be $110/acre based on historical flood damage to grain crops documented in a Madera County Agricultural Commissioner Disaster Report (Disaster Report) dated April 24, 2006. Due to the uncertainty in the location of benefits, the crops having the lowest damage per acre (barley and alfalfa) were selected for the analysis. (Note that the report shows damage to some agricultural lands were as high as $2,600 per acre.) Flood damage calculations and additional information on the Disaster Report are included as Attachment 9.4, page 3.
4. No damage occurs to buildings, structures, vehicles, or equipment.
5. The flooding does not result in casualties or require evacuation or rescue costs.

Due to some uncertainty where flooding would be avoided, several assumptions were made resulting in a low estimated benefit, so the flood damage analysis is considered reasonable.

Project: Project D - Root Creek In-Lieu Groundwater Recharge Project

Table 18 - Event Damage							
Hydrologic Event	Event Probability	Damage if Flood Structures Fail	Probability Structural Failure		Event Damage		Event Benefit (Million $)
			Without Project	With Project	Without Project	With Project	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
					(c) x (d)	(c) x (e)	(f) – (g)
San Joaquin River Flood Releases	100%	$0	1	0	$115,500	$0.00	$115,500

Notes:

1) Flood Damage Losses are based on the following assumptions:
   a) 2,100 AF/year (long-term average) of San Joaquin River floodwater is diverted into the project
   b) The floodwater would have inundated agricultural land planted with grain crops to a depth of 2 feet
   c) Damage to crops and land is $110/acre

2) The flood probability is 100% since the floodwater diversions of 2,100 AF represent a long-term average. Actual diversions would occur about one in every three years.

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Table 19 - Present Value of Expected Annual Damage Benefits Project: Project D - Root Creek In-Lieu Groundwater Recharge Project			
(a)	Expected Annual Damage Without Project (1)		**$115,500**
(b)	Expected Annual Damage With Project (1)		**$0**
(c)	Expected Annual Damage Benefit	(a) – (b)	**$115,500**
(d)	Present Value Coefficient (2)		**15.76**
(e)	**Present Value of Future Benefits** **Transfer to Table 20, column (e), Exhibit F: Proposal Costs and Benefits Summaries.**	**(c) x (d)**	**$1,820,280**

(1) This program assumes no population growth thus EAD will be constant over analysis period.

(2) 6% discount rate; 50-year analysis period (could vary depending upon life cycle of project).

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Attachment 9.1, Project E – Sierra National Forest Fuels Reduction Project

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Project E – Sierra National Forest Fuels Reduction Project

Relationship to other Projects

This fuels reduction project is located in the headwaters of the major rivers that flow to and through the county of Madera. It is the only one of the projects in the proposal that is located in the Foothill/Mountain area of the Madera IWMG region. Taken as a whole, all the projects will help to alleviate flooding through a combination of vegetation management, flood channel improvements, forestland management, and floodwater diversions.

The Arundo eradication and sediment removal projects increase flood flow capacities and reduce flooding hazards in the north and west portions of the region. The Forest Service fuel reduction project prevents the conditions that lead to floods and debris flows in the east (foothill) part of the region. The Root Creek Water District project will help to alleviate flooding common in low lying areas during winter storms through diverting the flood flows to beneficial use.

Costs

The Sierra National Forest Fuels Reduction project costs are detailed in Attachment 4.1, page 39 and explained in the budget notes. All costs associated with the fuels reduction activities are accounted for there. Annual cost of the project is broken out base on the expected number acres that will be completed based on Attachment 5.1, page 27 and are listed in Table 17. All matching funds listed in attachment 4.1E are from federally appropriated dollars.

Flood Damage Reduction Benefits

High severity wildfires can leave a watershed completely devoid of vegetation and ground cover. Surface soils and residual ash are then exposed to the direct impact of rain drops which break up fine particles and clog micropores (surface sealing) increasing surface runoff. High surface temperatures during a fire can also cause physical, chemical, and biological changes to soils that reduce infiltration and make them more susceptible to erosion. Increased soil water repellency due to fire has been documented in a wide variety of climates and soil types (see Cerda and Robichaud, 2009, and references therein). In the most severe cases, high temperatures will destroy soil structure and aggregation leaving a fine powdery surface that is easily eroded. Rainfall that is normally used in transpiration by vegetation becomes available for shallow subsurface flow and runoff. The combined affect is a rapid concentration of runoff with very high sediment loads, increasing the probability and magnitude of flooding and potentially resulting in debris flows.

Post fire debris flows are common in mountainous environments and can occur in response to short duration, low-frequency rainfall events (Cannon et al. 2008). Cannon and Gartner (2005) and Santi et al. (2008) have shown that most post-fire debris flows result from intense runoff and rilling that delivers large amounts of sediment and water to stream channel. The stream channels themselves then experience intense bed and bank erosions as in-channel sediment is remobilized and transported downstream in a highly destructive pulse of water, sediment, and debris. This is in contrast to slide-initiated flows that begin when a saturated hillslope experiences an abrupt failure resulting in large amounts of debris being delivered to the channel (infiltration triggered). Both type of debris and mud flows are covered under the National Flood Insurance Program (44 CFR Part 60). Post-fire flooding and debris flows can plug culverts, damage bridges and levees, and silt-up reservoirs (Cannon et al., 2007). According to the Durango Herald, Denver Water is still spending millions of dollars on reservoir dredging and watershed restoration from the Haymen Fire of 2002 (Abernethy, 2010).

The effect of wildfire on watershed hydrologic processes depends on the size and severity of the fire. Fire severity is determined to be low, moderate, or high based on the fire's effects to the hydrologic function of the soil. Conditions that are considered when rating the fire severity include the amount of surface cover remaining, presence or absence of fine roots in the top soil, water repellency, ash content and color, and damage to the soil structure. When considering the effects of fire on hydrologic processes and aquatic habitats, it is the percentage and distribution of moderate to high burn severity that is important. Fire burn severity on USFS land is evaluated by soil scientists and hydrologists from the Burn Area Emergency Response (BAER) team once the fire is contained.

Historical Flood Damage Data

There is little written information available for historical flooding within the Sierra National Forest (SNF) in the Madera region. The largest recent flood was the 1997 rain on snow event that was part of the same storm system that caused flooding through California. The 1997 event caused the washout and collapse of several road crossing on the SNF. Eight crossings were washed out in the Madera IWMG region on the SNF. These crossings were investigated by SNF Engineers for application to the Federal Highway Administration's Emergency Relief for Federally Owned Roads (ERFO) program. Total damages were estimated at $650,800 ($866,153 in 2009 dollars).

Flood insurance rate maps (FIRMs) and the Flood Insurance Study (FIS) for Madera County and Incorporated areas stopped at the administrative boundary of the SNF and so did not report any flooding information for county areas that exist within the boundary (see project map in Attachment 3.1). For the communities of Oakhurst and Unincorporated Areas near the boundary, the FIS reports minor localized flooding. The City of Madera has been subject to numerous floods 1938, 1943, 1945, 1950, 1952, 1955, 1956, 1958, 1962, 1963, and 1969. Hidden Dam, built along the Fresno River in 1976 provides flood storage to the city from the Fresno River, however moderate to severe localized flooding still occurs throughout the county.

Madera County has been included in federally declared disasters for flooding, mud and debris flows in 2006, 1997, 1995, 1993, 1986, and 1969 (http://www.fema.gov/femaNews/disasterSearch.do?action=Reset).

With and Without Project Conditions

Past management of SNF lands has left foothill and mountain watersheds in a hazardous condition. Intensive logging activities and fire suppression since the early 1900's has resulted in forest stands that are severely overstocked (too high of a tree density) and contain heavy loading of ground and ladder fuels (USDA-FS 2005a and 2005b). In addition, planted even-aged stand regeneration (e.g. plantations) was used to replace harvested trees. Many of these plantations are overgrown to the point where they have become wildfire hazards

Flooding potential for the with- and without- conditions requires the following information:

1. Probability of a wildfire of a given size occurring
2. Probability of a storm of a given intensity and magnitude of occurring (precipitation frequency), and/or the flow frequency for channel flow.
3. Estimation of the number of acres that would burn at moderate to high intensity in a fire of a given size
4. Runoff response from 1 -3.
5. Debris flow probability given 1, 2, and 4

To obtain estimates of the above data one could perform extensive numerical modeling that requires detailed data on topography, antecedent moisture conditions, weather, fuel loading, fire suppression response, pre and post burn runoff characteristics, and sediment availability. The data needed to do this is not readily available. Therefore, existing data and an empirical analysis of historic data from the SNF and neighboring forests, the Sequoia and the Stanislaus was used (Attachment 9.5, page 3).

The analysis provided in Attachment 9.5,page 3 shows that the increase in discharge associate with a wildfire can be estimated based on the percent of the burned area that burned at a high severity. For the without project conditions, the average value from the BAER reports of 12% was used (none of the fires in the BAER report had burned through recently treated areas).

A review of the literature has not revealed any reliable data on the effects of fuel treatments on the percent of a fire area that burns at high intensity. This is mostly because there have been very few fires that have burned through a treatment area. Most of the studies that have been done have examined the effects of fuel treatments on burn intensity, which is a measure of the effects of fire on the vegetation (Martinson and Omi 2003, Omi and Martinson 2007, and Skinner et al 2004). The effects of a fire on vegetation do not necessarily reflect the effect to the soil, although they can be grossly correlated (see Figure A-2 of Miler and Safford 2008). Further, the methods of fuel reduction (thinning, mastication, burning, etc.) were not the same in all cases. A modeling study by Stratton (2004) showed that fuel thinning treatment could reduce fire sizes and fire intensity (here measured in BTUs) by ~50%. Tolmie (2010), an experienced fuels management officer for the SNF estimates that this comparable from what she has observed and would apply to the SNF as well. The areas that will be treated will be brought to a condition that results in only a low to moderate burn severity; this is the goal of the project. However, a fire of any size and recurrence interval will not be exclusive to these treatment areas. Therefore, for the with-project condition it is assumed that the fire size will be 50% of that without treatment and the areas of high burn severity will be ~6% of the total burn area.

Using the above assumptions and the analysis in Attachment 9.5, page 3, it is now possible to predict the effects of a given fire on peak flow, and hence the physical benefits of the fuels reduction project. This was done for North Fork Willow Creek and the Fresno River at County Road 41.

North Fork Willow Creek

Return Period (fire and Q)	2	5	10	25	50	100
Unburned Discharges (cfs)	474	1077	1513	2392	3075	4098
Without Project						
Fire Size (ac)	657.000	4259.000	11363.000	32450.000	64021.000	118005.000
Acres burned at high severity	78.840	511.080	1363.560	3894.000	7682.520	14160.600
% increase in Q	33.483	83.047	133.799	222.809	309.995	417.278
Resulting Q (cfs)	*632.608*	*1971.443*	*3537.469*	*7722.913*	*12606.811*	*21196.110*
With Project						
With Project Fire Size (ac)	328.500	2129.500	5681.500	16225.000	32010.500	59002.500
Acres burned at high severity with project	19.710	127.770	340.890	973.500	1920.630	3540.150
% increase in Q	17.069	42.337	68.210	113.588	158.035	212.728
Q with project and Fire (cfs)	*554.821*	*1532.992*	*2545.092*	*5109.895*	*7934.242*	*12814.412*
Flood discharge reduction as a result of the project	**77.786**	**438.451**	**992.377**	**2613.019**	**4672.569**	**8381.698**

Fresno River at County Rd 41

Return Period (fire and Q)		2	5	10	25	50	100
Unburned Discharges (cfs)		1044	2267	3156	5004	6399	8462
Without Project							
Fire Size (ac)		657.000	4259.000	11363.000	32450.000	64021.000	118005.000
Acres burned at high severity		78.840	511.080	1363.560	3894.000	7682.520	14160.600
% increase in Q		33.483	83.047	133.799	222.809	309.995	417.278
Resulting Q (cfs)		*1392.926*	*4149.644*	*7377.651*	*16152.195*	*26236.618*	*43773.976*
With Project							
With Project Fire Size (ac)		328.500	2129.500	5681.500	16225.000	32010.500	59002.500
Acres burned at high severity with project		19.710	127.770	340.890	973.500	1920.630	3540.150
% increase in Q		17.069	42.337	68.210	113.588	158.035	212.728
Q with project and Fire (cfs)		*1221.650*	*3226.759*	*5307.976*	*10687.161*	*16512.318*	*26464.184*
Flood discharge reduction as a result of the project		**171.276**	**922.885**	**2069.675**	**5465.034**	**9724.300**	**17309.792**

It can be seen that fuel reduction can significantly reduce peak flows given the occurrence of a wildfire. The methods used to estimate these benefits are considered conservative. Reports of flow increases of orders of magnitude are common in the post-fire environment. Several BEAR team members use a rule of thumb that the post fire increase is 100% of the pre-burn increase. An attempt was made here to quantify the benefits based on empirical analysis of reported data on the western slopes of the Sierra Nevada Mountains.

Distribution of local, regional, and statewide benefits

The flood reduction benefits are local to regional scale benefits. No attempt was made to route the flows further downstream but the significant reductions in discharge as a result of the project will certainly be felt down to the next downstream reservoir. Houses and property along the drainages will realize direct benefits from the reduction of discharge and sediment.

Identification of beneficiaries

Beneficiaries of this project include citizens in the cities of Oakhurst, Madera, North Fork, Bass Lake, and those that live on county parcels within the SNF administrative boundary.

When the benefits will be realized

The protection from wildfire should last between 10 and 20 years when future fuels reductions will need to take place. However, this can then be accomplished through the use of low-intensity prescribed fire at a much reduced cost indefinitely.

Uncertainty associated with the benefits

The values used in the above analyses have uncertainty involved with the USGS regression equations, the frequency analysis of wildfire sizes, and the runoff response to those fires. However, the values and methods used are considered conservative. No attempt was made to bulk flow from sediment and discharge increases in the post-fire environment have been reported anywhere between 5% and 300%

IX. Adverse Impacts

Mastication has little chance of adversely impacting water quality or other resources. The excavator walks on top of a bed of already shredded material, preventing soil compaction and disturbance. Small areas of less than 20 ft2 of disturbance can be expected in areas where the machine turns on its tracks. These will have little impact on the soil hydrologic function.

The largest potential for adverse impact is during the dozer piling of slash. Poor operators can cause significant soil disturbance and remove too much ground cover. Forest Service Best Management Practices (BMPs) and contract requirements are used to minimize these impacts by limiting slopes on which dozers can operate to less than 35%, requiring operations on dry ground, and by requiring contractors and operators to repair areas of excessive disturbance. Wildlife is protected through the use of Limited Operating Periods (LOPs) which operations to be conducted at times when noise would not cause a nuisance.

Table 19

Flood inundation mapping could not be attempted as the only source of topographic information is the USGS quadrangles with 40 ft contour intervals. This gives a maximum vertical accuracy of 20 ft which is completely insufficient for flood inundation mapping. The values in table 19 were taken from the FRAM spreadsheet (Attachment 9.5, page 13) and Table 16. Two sections of the FRAM spreadsheet were used: residential and special cases. By examining the topograpchic map, aerial photos, and the FEMA 100-year Special Flood Hazard Area (SFHA) for Fresno River from County Rd 41 to the limit of study, several structures were found that were well within the SFHA. In addition, several structures in the vicinity of Cedar Valley were located immediately next to the river. In all, 18 structures were rural residential structure and 2 were in Oakhurst and were considered Urban residential. For each rural residential building it was assumed that there was one shed/barn for each. In addition, there are seven trailers located in the SFHA that belong the local school. These were entered into FRAM as mobile home. The total structures are shown below:

Rural Residential	17
Rural Barns/sheds	17
Urban Residential	2
Mobile Home	7

Because these structures were well within the SFHA, or immediately adjacent to the river on flat ground, it was assumed they would be inundated by 2-feet of flood water during the un-burned 100-year flood (base flood).

For the with- and without- project conditions, the combined (joint) probability of wildfire and flood was used for the recurrence interval in the FRAM spreadsheet. For example, the 4-year ARI event in the FRAM spreadsheet is combined ARI for a 2-year fire and a 2-year flood (0.5*0.5 = 0.25 1/0.25 = 4).

The combined 100-year ARI for fire and flood (produces a discharge close to the base flood (i.e. 10 yr flood x 10 yr fire) has a discharge slightly less than the base flood. Therefore the "flood depth above ground" for this event is 2 feet. Following a similar logic, the following depths were used for the 4, 25, and 100 combined ARI events.

Combined ARI	Without Project Depth	With Project Depth
4	0	0
25	1	0
100	2	1

The "special cases" tab was populated based on the damage incurred during the 1997 flood discussed above. According to the North Fork Willow Creek USGS gage (site No. 11242400) the peak discharge on the day of that flood was 2,540 cfs. This is approximately the 25-year flood (2392 cfs). Most forest road culverts at the time they were built were designed for the 20-50 year flow. There are hundreds of undersized culverts on the SNF. To estimate damage due to road crossing washout, the damage (converted to 2009 dollars) done by the 1997 storm was scaled using the ratio of the expected discharge during the 4, 25, and 100 combined ARI events to the 1997 flow of 2,540 cfs for the with and without position.

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Table 17- Annual Cost of Project (All costs should be in 2009 Dollars) Project: Project E - Sierra National Forest Fuel Reduction Project									
	Initial Costs	Operations and Maintenance Costs (1)						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total cost From Table 7 (row (i), column (d))	Admin	Operation	Maintenance	Replacement	Other	Total Costs (a) +…+ (f)	Discount Factor	Discounted Costs (g) x (h)
2009	$410,385						$410,385	1.000	$410,385
2010	$129,950						$129,950	0.943	$122,543
2011	$247,052						$247,052	0.890	$219,876
2012	$873,775						$873,775	0.840	$733,971
2013	$851,775						$851,775	0.790	$672,562
2014	$542,870						$542,870	0.742	$402,931
2015	$3,568						$3,568	0.698	$2,489
Project Life								…	
Total Present Value of Discounted Costs (Sum of Column (i)) Transfer to Table 20, column (c), Exhibit F: Proposal Costs and Benefits Summaries									$2,564,757
Comments:									

(1) The incremental change in O&M costs attributable to the project.

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Table 19 - Present Value of Expected Annual Damage Benefits			
Project: **Project E - Sierra National Forest Fuel Reduction Project**			
(a)	Expected Annual Damage Without Project (1)		$ 487,552
(b)	Expected Annual Damage With Project (1)		$ 311,219
(c)	Expected Annual Damage Benefit	(a) – (b)	**$176,333**
(d)	Present Value Coefficient (2)		**15.76**
(e)	**Present Value of Future Benefits** **Transfer to Table 20, column (e), Exhibit F: Proposal Costs and Benefits Summaries.**	**(c) x (d)**	**$2,779,013**

(1) This program assumes no population growth thus EAD will be constant over analysis period.
(2) 6% discount rate; 50-year analysis period (could vary depending upon life cycle of project).

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